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TECHNICAL REPORT

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EVALUATION OF HIGHLY WEATHER-RESISTANT CORRUGATED FIBERBOARD

by

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FOREWORD

The climatic conditions of Southeast Asia have had an extremely deteriorative effect on the weather-resistant corrugated fiberboard (V3c) presently in the Government packaging system. The result is that V3c corrugated fiberboard is not currently permitted in the fabrication of exterior shipping containers for use in Southeast Asia.

This study is concerned with the evaluation and comparison of a "highly weather-resistant" corrugated fiberboard with Standard V3c corrugated fiberboard. The new material is composed of wet-strength kraft liners with an all-important wet-strength kraft corrugating medium. The V3c material presently in the system is composed of weather-resistant liners and the corrugating medium is made of virgin or reclaimed fibers; therefore, it does not have the weather-resistant quality of the wet-strength kraft material.

The evaluation was accomplished under the Applications Engineering Program.

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ABSTRACT

This study was conducted to determine the physical properties of a new "highly weather-resistant" single-wall corrugated fiberboard material as compared to grade V3c of Federal Specification PPP-F-320 and to evaluate its material performance and container performance under various environmental conditions and as containers in unit loads.

The new fiberboard and the V3c control fiberboard were tested in accordance with American Society for Testing Materials standards or with the requirements of Federal Specifications, utilizing five various environmental conditions. Both materials were tested for ply separation, water absorption, scoreability and bending, bursting strength (wet and dry), and basis weight. Containers made of both materials were subjected to drop tests and compression tests after conditioning. Small size unit loads of both types of containers, sheathed and capped with V2s solid fiberboard, were given compression tests after environmental conditioning.

It was found that the performance of the new material, because of the wet strength kraft used for the corrugating medium instead of virgin or reclaimed fiber corrugating medium, was superior to the V3c material in water absorption, wet Mullen, and in container drop tests after water spray conditions. The container drop tests performances after total immersion were very similar. The V3c containers slightly outperformed the new material containers in compression strength after long periods of storage at high temperatures and humidities; however, the new material showed greater durability under water spray and total immersion conditions.

EVALUATION OF

HIGHLY WEATHER-RESISTANT CORRUGATED FIBERBOARD

1. Introduction. A continuing investigation is being conducted to develop improved materials for fiberboard containers used for the shipment of military supplies to overseas locations such as Southeast Asia. Some types of corrugated fiberboard containers appear to be unstable in the hot-humid climate of that area. Deficiencies have ranged from slight delamination to complete degradation of the containers.

The fiberboard industry initiated a project to improve the stability of the V3c material, and after extensive study developed a new, corrugated fiberboard, termed VOc, which is designed to be highly weather resistant.

One of the major differences between this board and the V3c material is that the corrugating material is made of a highly weather-resistant kraft rather than of virgin or reclaimed fibers. Theoretically, the composition of the new VOc material would provide sufficient resistance to degradation from the high humidity conditions of Vietnam. Assurance of adequate performance, however, would be provided through test requirements beyond those which are applicable to the currently used V3c material. These requirements would include an increase in Mullen or bursting strength (wet and dry) as well as a water absorption test.

This study was designed to compare the VOc material to the present grade of V3c, through evaluation tests. In addition to these tests, both materials were fabricated into containers and tested after being subjected to various periods of environmental conditioning. Since consolidated shipments are presently being made to Vietnam, unit loads consisting of containers of both of the materials, sheathed and capped in V2s fiberboard, were also tested after periods of environmental conditioning.

2. Materials.

a. Special corrugated material. The special corrugated material, designated as VOc by its manufacturer, is made up to two 90-pound, wet-strength kraft liners with a 38-pound wet-strength kraft corrugating medium.

b. Control material. The control material was corrugated fiberboard conforming to class weather-resistant, grade V3c of Federal Specification PPP-F-320. This material was made up of two 0.023-inch weather-resistant liners with an 0.010-inch corrugated medium of virgin or reclaimed fibers.

3. Containers and Unit Loads.

a. Containers.

(1) VOc containers were furnished under the direction of the Fibre Box Association by the International Paper Co., knocked down, with the manufacturer's joint stapled, and in the following quantities:

(a) 80 2-1/2-can size, style RSC (16-1/4" x 12-3/16" x 9-3/8").

(b) 20 Full standard size clothing boxes (23-1/2" x 15" x 15").

(2) V3c control containers were fabricated in-house, with dimensions the same as the containers furnished by the manufacturer.

All RSC containers, both V3c and VOc, were set up as follows:

The bottom flaps and manufacturer's joints of the containers were stapled with 0.103-inch x 0.023-inch staples with 3/8-inch crowns. The top flaps of all RSC containers were fastened with a weather-resistant adhesive. In the empty containers used for compression tests, the flaps were clamped together with two plywood boards until dry. The containers for the drop tests were loaded with 24 No. 2-1/2-size cans filled with water, so that the weight of the filled containers was approximately 45 pounds. They were inverted after the application of the adhesive and allowed to dry. The loaded containers were reinforced with 1/2-inch x .015-inch steel strapping, one lengthwise encircling the top, bottom, and ends, and one girthwise encircling the top, bottom, and sides.

The clothing boxes were to be used for compression tests in unit loads and therefore were set up as follows:

The bottom flaps were stapled with 0.103-inch x 0.023-inch staples with 3/8-inch crowns, and the top flaps were fastened with tape meeting the requirements of Federal Specification PPP-T-76.

b. Unit loads.

Number of unit loads	Contents	Container arrangement	Dimensions (inches)
3	8 V3c, 2-1/2-can-size containers	2 x 2 x 2	34 x 26-3/4 x 20
3	8 VOc, 2-1/2-can-size containers	2 x 2 x 2	34 x 26-3/4 x 20
2	8 V3c, clothing containers	2 x 2 x 2	48-1/2 x 31-1/2 x 31-1/2
2	8 VOc, clothing containers	2 x 2 x 2	48-1/2 x 31-1/2 x 31-1/2

The small unit loads were made up with V2s fiberboard sheathing and top cap. The sheathing body of each unit load was full height, and had stitched joints located at two diagonally opposite corners. The flaps of the top cap overlapped the sheathing approximately 2 inches. All loads were reinforced with 3/8-inch x .015-inch nonmetallic strapping placed two lengthwise and two girthwise.

It should be noted that due to their size and the fact that the containers were empty, the small loads were not constructed on pallets. This was done so that the loads could be handled and tested individually and not hindered by a pallet.

4. Equipment. The Ohaus Triple Beam Balance (sensitivity - 0.1 gm and capacity - 2610 gms) was used to make the basis weight and moisture absorption determinations, Mullen Tester to make the wet and dry burst tests, and 10,000-pound Tinius Olsen Compression Tester for conducting the compression tests. Drop testing was done on the Gaynes Drop Tester.

5. Environmental Conditions. During the course of test evaluation all containers and unit loads of containers were subjected to one or more of the following environmental conditions:

a. Standard Conditions - 73° F., 50% R.H. (Relative Humidity) for a minimum of 48 hours.

b. High Temperature--High Humidity Conditions, 100° F., 90% R.H. for 30 days.

c. High Temperature--High Humidity Conditions, 100° F., 90% R.H. for 60 days.

d. Water Spray, 3 inches per hour for 24 hours.

e. Total Water Immersion, specimen totally immersed in water for 24 hours.

6. Evaluation Tests.

a. Container and unit load evaluations. The tests used for evaluating the containers and unit loads of containers were as follows:

(1) Compression Tests (ASTM Standard 642). The load was applied at a rate of 0.4 inches per minute in top to bottom compression.

(2) Drop Tests (ASTM Standard 775). The containers were subjected to diagonally opposite corner drops from a height of 30 inches.

NOTE: No drop tests were performed on the unit loads.

b. Material evaluation. The tests used for evaluating the materials were as follows:

(1) Ply Separation Test; conducted in accordance with the requirements of Federal Specification PPP-F-320.

(2) Water Absorption Test; conducted in accordance with the requirements of Federal Specification PPP-F-320.

(3) Bursting Strength Test (wet and dry); ASTM 774.

(4) Scoreability and Bending Test; conducted in accordance with the requirements of Federal Specification PPP-F-320.

(5) Basis Weight; conducted in accordance with Method No. 110 of Federal Specification UU-P-31b.

VOc material for evaluation was cut from the containers furnished by the manufacturer.

7. Test Procedure.

a. Component evaluation.

(1) Ply Separation Test. Ten 6 x 10 inch samples of each type of fiberboard were totally immersed in fresh clean tap water at 73° F. for 24 hours. The samples were removed and immediately tested for ply separation, in accordance with Federal Specification PPP-F-320.

(2) Water Absorption Test. Ten samples of each type of fiberboard were conditioned at 73° F. and 50% R.H. for 48 hours, and weighed on the Ohaus Triple Beam Balance. The samples were then totally immersed in fresh clean tap water at 73° F. for 24 hours. Each sample was removed, excess surface water drained off, and the sample weighed. The percent water pickup was computed as follows:

$$\frac{\text{Wet Weight} - \text{Dry Weight}}{\text{Dry Weight}} \times 100 = \text{Percent Water Absorption}$$

(3) Bursting Strength Test (wet and dry). Six samples of each type of fiberboard were conditioned at 73° F. and 50% R.H. for 48 hours for dry burst determination. Each sample was then tested on the Mullen tester in accordance with ASTM Standard 744. Six bursts were made through each sample with an equal number of bursts being made from alternate sides of the fiberboard. For wet burst determinations, six samples of each fiberboard material were conditioned by total immersion in fresh clean tap water at 73° F. for 24 hours in accordance with Federal Specification PPP-F-320. Each sample was removed, excess surface water drained off, and tested as described above for dry samples.

(4) Scoreability and Bending Test. Ten 12- by 12-inch samples of each type of fiberboard were conditioned at 73° F. and 50% R.H. for 48 hours and then each sample received two scores passing through the center. One score was parallel to the flutes, and the other was perpendicular to the flutes. Each sample was then folded 180 degrees in the proper direction along both scorelines.

(5) Basis Weight Tests. Ten 10- by 10-inch samples of both types of fiberboard were conditioned at 73° F. and 50% R.H. for 48 hours. Each sample was then weighed on the Ohaus Triple Beam Balance and the average weight in grams of the ten samples of each type of fiberboard was converted to obtain the basis weight in pounds per 1000 square feet.

b. Container and Unit Load Evaluation.

(1) Compression Test.

(a) Containers. Five empty, style RSC No. 2-1/2-can-size containers, fabricated from both types of fiberboards, were subjected to top-to-bottom compression tests after exposure to each of the conditions cited in Section 6, Environmental Conditions. After exposure to the given conditions for the required period of time, containers were removed from the conditioning atmosphere, one at a time, and immediately tested on the Tinius Olsen Compression machine at a platen speed of 0.4 inches per minute.

(b) Unit Loads. Unit loads containing empty containers of each type of material were subjected to compression tests at a platen speed of 0.4 inches per minute, immediately after experiencing the following environmental conditions:

Unit Load Contents	Conditions	Exposure Time
2-1/2-can-size containers	Standard 73° F. and 50% R.H.	48 hours (minimum)
2-1/2-can-size containers	100° F. and 95% R.H.	30 days
2-1/2-can-size containers	100° F. and 95% R.H.	60 days
Clothing boxes	Standard 73° F. and 50% R.H.	48 hours (minimum)
Clothing boxes	Water Spray (3"/hour)	24 hours

(2) Drop Tests. Five filled No. 2-1/2-can-size containers, style RSC, of each type of fiberboard were subjected to diagonally opposite corner drop tests after exposure to each of the conditions cited in Section 5. Environmental Conditions. After exposure to the given conditions for the required period of time, the containers were removed from the

conditioning atmosphere, one at a time, and immediately tested. During the drop tests the number of drops to the first one-inch tear, six-inch tear, complete scoreline tear, and spillage of contents were recorded. The first apparent can leakage was also noted. The criterion for failure was a complete scoreline tear or spillage of contents. A complete scoreline tear is defined as a split through the fiberboard thickness across the entire length of any scoreline.

8. Test Results.

a. Component Evaluation. The following are average results of the tests performed. Detailed results of the Basis Weight, Mullen, and Water Absorption tests can be found in Tables I, II, and III of the Appendix.

Test	Conditions and Time	Results (average - 10 samples) V3c	Results (average - 10 samples) V0c
Basis Weight	Standard (48 hours)	222 lbs/1000 ft^2	239 lbs/1000 ft^2
Bending Test	Standard (48 hours)	100% passed	100% passed
Mullen Test - Dry	Standard (48 hours)	510 psi	472 psi
Mullen Test - Wet	24 hours immersion	165 psi	259 psi
Ply Separation	24 hours immersion	100% passed	100% passed
Water Absorption	24 hours immersion	108% passed	74% passed

b. Container and Unit Load Evaluation. The following are average results of the tests performed. Detailed results of the compression and drop tests on containers are in Tables IV and V and Figures 1, 2, and 3 in Appendix.

(1) Compression Test Results.

No. 2-1/2-can-size containers:

		Results (average - 5 containers)			
		V3c		V0c	
Conditions	Time	Peak Load (lbs)	Deflection (inches)	Peak Load (lbs)	Deflection (inches)
Standard	48 hours	1580	0.76	1632	0.48
High temperature and humidity	30 days	1132	0.63	1116	0.46
High temperature and humidity	60 days	861	0.45	785	0.42
Water spray (3"/hour)	24 hours	203	0.65	230	0.69
Total immersion	24 hours	159	0.71	204	0.60

(1) Compression Test Results. (Continued)

Unit loads (one each):

Conditions	Time	Results (average - 5 containers) V3c Peak Load (lbs)	V3c Deflection (inches)	V0c Peak Load (lbs)	V0c Deflection (inches)
V2s sheath and cap with empty No. 2-1/2-can-size containers.					
Standard	48 hours	6450	1.12	7520	1.18
High temperature and humidity	30 days	4470	1.12	4790	0.92
High temperature and humidity	60 days	4350	1.00	4310	0.89
V2s sheath and cap with empty clothing boxes.					
Standard	48 hours	8170	1.19	7920	1.37
Water spray (3" /hour)	24 hours	4360	1.88	4400	2.20

(2) Drop test results.

V3c containers:

Conditions	Time	Results (average - 5 containers, No. of drops to first: 1" tear	6" tear	Failure scoreline	Spillage
Standard	48 hours	3.6	12.2	13.8	-
High temperature and humidity	30 days	6.8	16.0	18.8	-
High temperature and humidity	60 days	10.6	15.8	20.0	-
Water spray (3"/hour)	24 hours	3.0	7.2	11.4	-
Total immersion	24 hours	1.6	5.4	-	6.6

(2) Drop test results. (Continued)

VOc containers:		Results (average - 5 containers)			
		No. of drops to first:			
Conditions	Time	1" tear	6" tear	Failure scoreline	Spillage
Standard	48 hours	3.4	11.2	14.2	-
High temperature and humidity	30 days	7.4	18.4	21.4	-
High temperature and humidity	60 days	9.6	20.2	25.2	-
Water spray (3"/hour)	24 hours	9.8	19.0	25.2	-
Total immersion	24 hours	2.2	5.0	-	6.4

9. Discussion.

The component evaluation results show that the VOc material performed better than the V3c material in wet bursting strength and water absorption, and was equal to V3c in bending and ply separation properties. The V3c material lost 68% of its strength in wet burst as compared to a loss of 46% for VOc. The 74% water absorption for VOc was very close to the proposed 80% specification requirement.

The nonpaired equal size group "t" test method was used for the statistical analysis of the component evaluation, container drop tests, and container compression test results. The results of these analyses are as follows:

Test Performed	Statistical Results
Component Evaluation	
Basis Weight	No significant difference.
Bending Test	No significant difference.
Mullen - Dry	No significant difference.
Mullen - Wet	VOc better.
Ply Separation	No significant difference.
Water Absorption	VOc better.

Test Performed	Statistical Results
Drop Tests on Containers	
Standard Conditions	No significant difference.
High Temperature & Humidity (30 Days)	No significant difference.
High Temperature & Humidity (60 Days)	No significant difference.
Water Spray (24 Hours)	VOc better.
Total Immersion (24 Hours)	No significant difference.
Compression Tests on Containers	
Standard Conditions	No significant difference [1].
High Temperature & Humidity (30 Days)	No significant difference [1].
High temperature & Humidity (60 Days)	V3c better.
Water Spray (24 Hours)	VOc better.
Total Immersion (24 Hours)	VOc better.

[1] It should be noted that although there was no significant difference of these peak loads, the deflection of the V3c under these conditions was much greater than that of the VOc. This is an important factor in favor of VOc when used with nonsupporting loads.

Pulling of staples from the bottom flaps, and the resultant "racking" of containers is also an index of material strength. During this comparison study, the performance of containers made from the two types of materials was quite similar in this regard after drop-testing containers which had been subjected to environmental conditioning as discussed above.

10. Conclusions.

Based on the test results of this report, it is concluded that:

a. The VOc material was superior to the V3c material in water absorption and wet Mullen tests, and was equal to the V3c material in all other areas of component evaluation.

b. The VOc material was slightly superior in compression performance after testing under water spray and total immersion conditions, and slightly inferior in compression after 60 days high temperature and humidity storage. There was no significant difference in the compression results of the two materials after standard conditions and 30 days storage at high temperature and humidity.

c. The two materials showed no significant differences physically in drop-test results. After exposure to water spray conditions, however, the VOc material appeared more durable.

d. The two materials used as containers in sheathed and capped unit loads and exposed to various environmental conditions and compression tests, performed similarly with the V3c giving a slightly superior performance after extended periods of storage at high temperatures and humidities.

APPENDIX

Detailed results of material tests and container tests are as follows:

Table I - Basis weight of fiberboard samples.
(Sample size = 10" x 10")

Sample Number	Weight (grams) V3c	Weight (grams) V0c
1	69.25	74.85
2	70.35	75.90
3	69.85	75.50
4	70.50	76.15
5	70.45	75.20
6	70.50	75.90
7	69.85	76.20
8	70.35	75.20
9	69.25	75.50
10	70.35	75.20
Average	70.07	75.56

<u>Calculations</u>:

<u>V3c</u>: $\frac{70.07 \text{ gms}}{100 \text{ in}^2} \times \frac{144 \text{ in}^2}{1 \text{ ft}^2} \times \frac{1 \text{ lb}}{453.6 \text{ gms}} \times 1000 = 222 \text{ lbs}/1000 \text{ ft}^2$

<u>V0c</u>: $\frac{75.56 \text{ gms}}{100 \text{ in}^2} \times \frac{144 \text{ in}^2}{1 \text{ ft}^2} \times \frac{1 \text{ lb}}{453.6 \text{ gms}} \times 1000 = 239 \text{ lbs}/1000 \text{ ft}^2$

Table II - Mullen Test (burst) of fiberboard samples.

Sample Number	Dry V3c (psi)	Dry VOc (psi)	Wet V3c (psi)	Wet VOc (psi)
1	475.0	470.8	176.6	275.0
2	518.3	480.0	166.6	265.0
3	543.3	451.6	165.0	248.3
4	528.3	501.6	155.0	259.2
5	490.0	463.3	163.3	250.0
6	508.3	465.0	166.6	256.6
Average	510.5	472.0	165.4	259.0

Each sample figure above is an average of six bursts on each sheet.

Table III - Water absorption test of fiberboard samples.

Sample Number	V3c Dry wt. (grams)	V3c Wet wt. (grams)	V3c % H_2O pick-up	V0c Dry wt. (grams)	V0c Wet wt. (grams)	V0c % H_2O pick-up
1	52.50	109.30	108.19	52.60	92.20	75.28
2	52.25	109.90	110.33	53.15	93.55	76.01
3	52.30	108.35	107.17	52.80	93.60	77.27
4	51.70	108.25	109.38	52.60	90.80	72.62
5	51.75	106.70	106.18	52.30	91.20	74.37
6	52.40	109.50	108.96	53.65	92.80	72.97
7	51.95	109.30	110.74	53.60	93.20	73.88
8	52.40	108.65	107.34	53.90	93.10	72.72
9	52.55	108.15	105.80	52.90	91.80	73.53
10	51.30	107.90	110.33	52.70	90.60	71.53
Average			108.44			74.02

Calculations: $\frac{\text{Wet Weight-Dry Weight}}{\text{Dry Weight}} \times 100 = \%$ Water Absorption.

Table IV - Compression tests of No. 2-1/2-can-size containers (empty).

Conditions: Standard (72° F. and 50% R.H.) - Time 48 Hours (Minimum).

Container Number	V3c Peak load (lbs)	V3c Deflection (inches)	VOc Peak load (lbs)	VOc Deflection (inches)
1	1450	0.65	1520	0.48
2	1320	0.99	1480	0.51
3	1850	0.93	1820	0.51
4	1860	0.62	1750	0.50
5	1420	0.60	1590	0.42
Average	1580	0.76	1632	0.48
High Temperature and Humidity - Time 30 Days				
1	920	0.60	1020	0.47
2	1070	0.58	1190	0.46
3	1440	0.86	1080	0.42
4	1150	0.54	1040	0.48
5	1080	0.57	1250	0.45
Average	1132	0.63	1116	0.46
High Temperature and Humidity - Time 60 Days				
1	880	0.42	785	0.45
2	845	0.42	800	0.35
3	830	0.50	790	0.48
4	840	0.40	770	0.40
5	910	0.48	780	0.42
Average	861	0.45	785	0.42
Water Spray at 3"/Hour - Time 24 Hours				
1	182	0.59	249	0.74
2	210	0.62	240	0.90
3	210	0.77	215	0.50
4	186	0.53	212	0.78
5	230	0.76	236	0.51
Average	203	0.65	230	0.69
Total Immersion - Time 24 Hours				
1	170	0.71	230	0.48
2	174	0.69	184	0.61
3	154	0.67	218	0.64
4	152	0.74	200	0.69
5	146	0.75	188	0.59
Average	159	0.71	204	0.60

Table V - Drop tests of No. 2-1/2-can containers after various conditions.

Standard Conditions - 48 Hours

V3c

Container Number	1" tear	6" tear	*First can leak	Failure
1	**5 (5-3)	12 (6-3)	7	16 (6-1)
2	3 (5-1)	11 (5-1)	8	13 (5-1)
3	4 (6-1)	11 (6-4)	8	12 (6-4)
4	3 (6-1)	13 (6-2)	-	14 (6-3)
5	3 (5-1)	14 (6-1)	6	14 (6-1)
Average	3.6	12.2		13.8

VOc

Container Number	1" tear	6" tear	*First can leak	Failure
1	3 (5-3)	12 (5-1)	-	13 (5-1)
2	3 (5-1)	12 (5-1)	12	14 (6-3)
3	4 (6-1)	10 (6-1)	7	14 (5-1)
4	4 (6-1)	12 (6-1)	6	14 (6-1)
5	3 (5-1)	10 (6-1)	11	16 (6-1)
Average	3.4	11.2		14.2

High Temperature and Humidity - 30 Days

V3c

Container Number	1" tear	6" tear	*First can leak	Failure
1	6 (5-3)	18 (5-1)	14	19 (5-1)
2	7 (5-1)	15 (5-1)	15	19 (5-1)
3	7 (5-1)	16 (5-1)	14	19 (5-1)
4	7 (5-1)	15 (5-1)	-	19 (5-1)
5	7 (5-1)	16 (5-3)	14	18 (5-3)
Average	6.8	16.0		18.8

VOc

Container Number	1" tear	6" tear	*First can leak	Failure
1	12 (6-1)	21 (5-1)	7	25 (5-1)
2	7 (5-1)	16 (6-1)	7	18 (6-1)
3	2 (5-1)	14 (6-1)	2	18 (6-1)
4	8 (6-1)	21 (6-1)	4	24 (6-1)
5	8 (6-1)	20 (5-1)	5	22 (5-1)
Average	7.4	18.4		21.4

Table V - Drop tests of No. 2-1/2-can containers after various conditions. (Continued)

Container Number	1" tear	6" tear	*First can leak	Failure
High Temperature and Humidity - 60 Days				
V3c				
1	**13 (5-1)	18 (6-1)	20	25 (6-1)
2	6 (6-1)	12 (6-1)	10	18 (6-1)
3	11 (6-3)	18 (5-1)	6	21 (5-1)
4	12 (5-3)	16 (6-1)	6	18 (6-1)
5	11 (5-3)	15 (6-1)	8	18 (6-1)
Average	10.6	15.8		20.0
V0c				
1	10 (6-1)	15 (5-1)	10	23 (6-2)
2	8 (6-3)	24 (6-1)	16	26 (6-1)
3	7 (5-1)	22 (5-3)	8	30 (6-2)
4	11 (5-3)	22 (5-1)	2	25 (5-1)
5	12 (5-3)	18 (5-1)	7	22 (6-1)
Average	9.6	20.2		25.2
Water Spray at 3"/Hour - 24 Hours				
V3c				
1	5 (5-3)	8 (5-3)	3	15 (5-1)
2	1 (6-1)	7 (6-1)	3	10 (6-1)
3	4 (5-1)	7 (6-1)	4	11 (6-1)
4	3 (5-1)	7 (5-1)	6	13 (5-1)
5	2 (5-3)	7 (5-1)	7	8 (5-1)
Average	3.0	7.2		11.4
V0c				
1	7 (5-1)	16 (5-1)	5	22 (5-1)
2	4 (5-1)	16 (6-1)	12	24 (6-1)
3	12 (6-1)	23 (6-3)	-	26 (6-1)
4	13 (6-1)	21 (6-1)	13	28 (6-1)
5	13 (6-1)	19 (6-3)	16	26 (5-3)
Average	9.8	19.0		25.2

Table V - Drop tests of No. 2-1/2-can containers after various conditions. (Continued)

Total Immersion - 24 Hours

V3c

Container Number	1" tear	6" tear	*First can leak	Failure
1	**1 (5-3)	5 (6-4)	-	6 (6-4)
2	1 (6-1)	6 (6-3)	-	7 (5-3)
3	2 (5-3)	4 (6-2)	-	5 (6-2)
4	2 (6-1)	6 (6-3)	-	7 (5-1)
5	2 (5-3)	6 (6-3)	-	8 (6-3)
Average	1.6	5.4		6.6

V0c

Container Number	1" tear	6" tear	*First can leak	Failure
1	1 (5-3)	5 (5-3)	-	6 (5-3)
2	2 (6-3)	3 (6-3)	-	4 (6-1)
3	3 (5-3)	6 (6-2)	-	7 (6-3)
4	2 (5-3)	6 (6-1)	-	7 (5-3)
5	3 (5-3)	5 (6-1)	-	8 (5-3)
Average	2.2	5.0		6.4

* Numbers in this column represent the drop in which the first leakage due to can failure was noticed.

** Figures in the drop-test results column are as follows: The first figure is the drop at which the tear occured, and the figures in parenthesis are the container surfaces adjacent to the scoreline that tore (see Figure III).

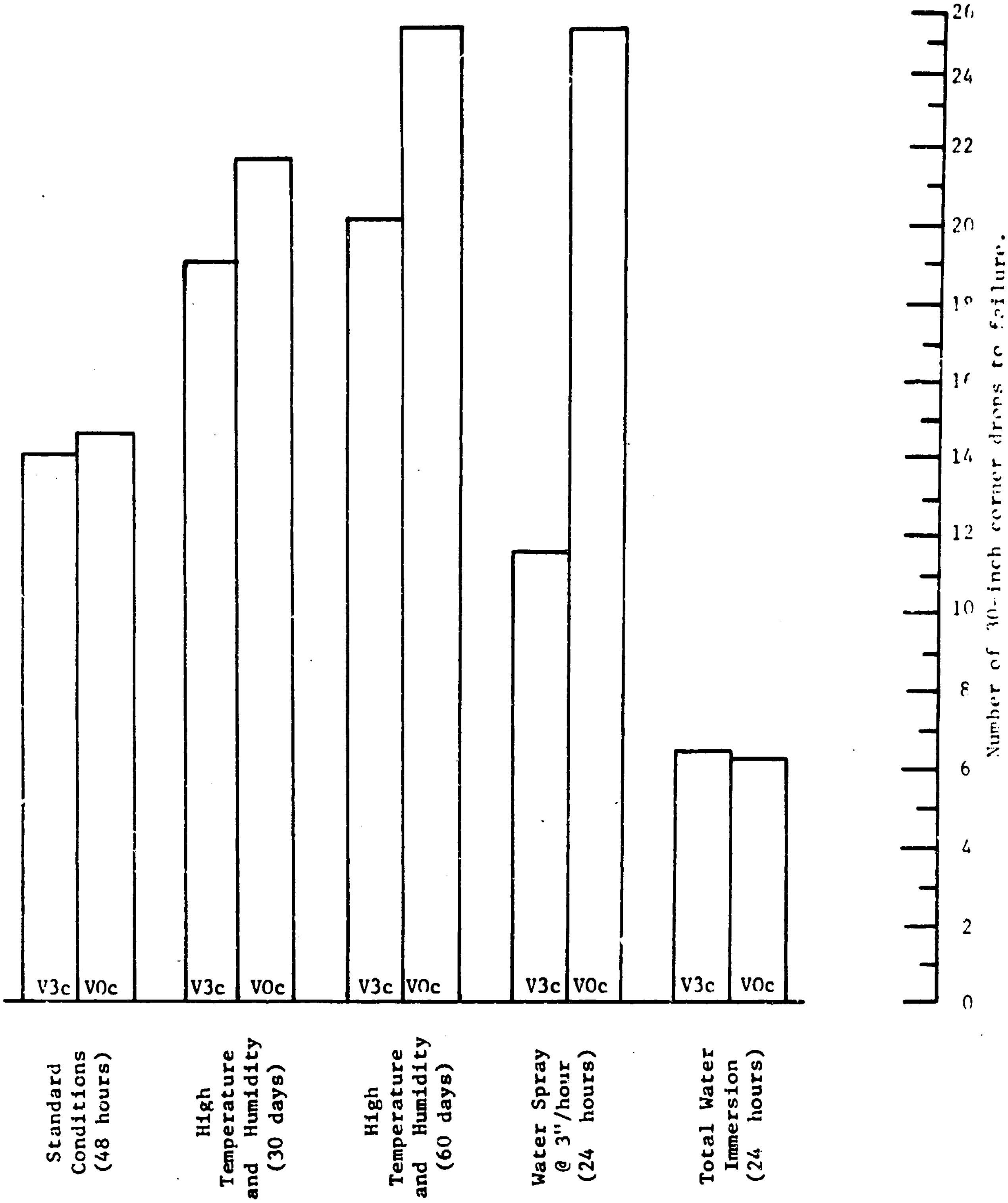

Figure 1. Drop test results (2-1/2-can-size containers).

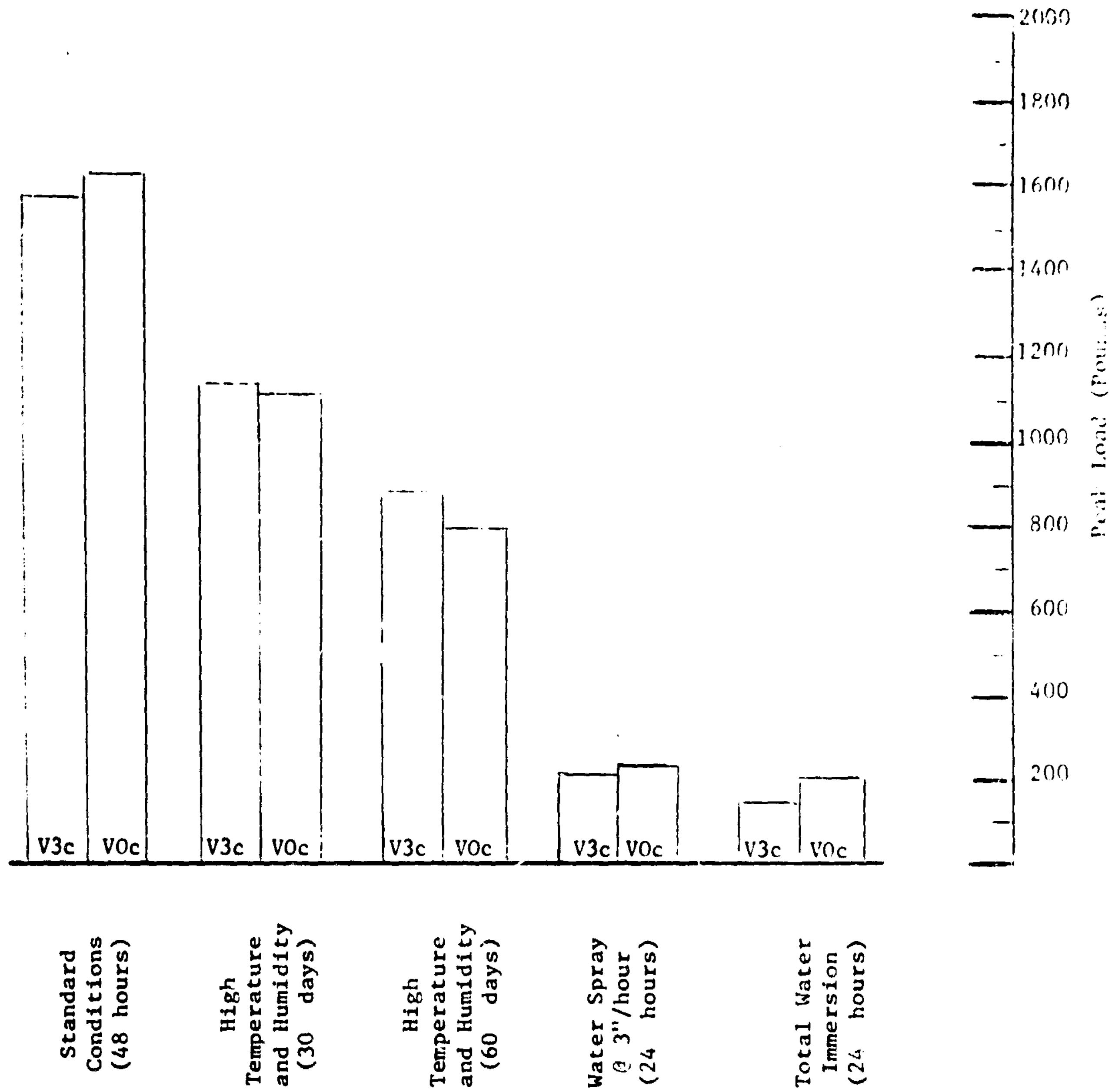

Figure 2. Compression test results (2-1/2-can-size containers).

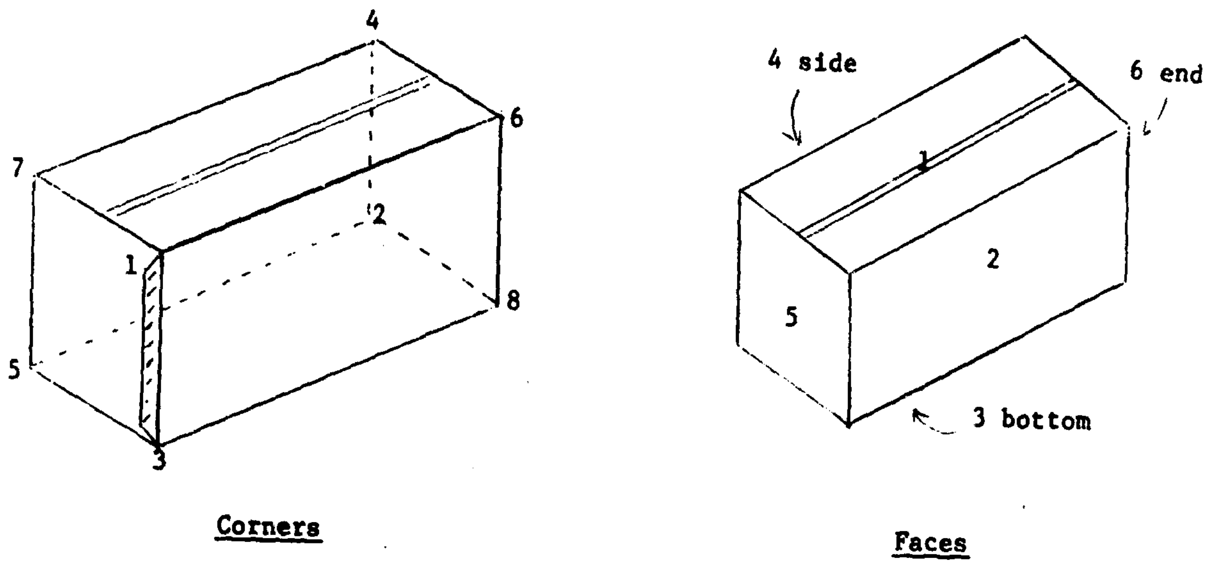

Figure 3. Identification of faces and corners of containers.

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Security Classification

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13. ABSTRACT

This study was conducted to determine the physical properties of a new "highly weather-resistant" single-wall corrugated fiberboard material as compared to grade V3c of Federal Specification PPP-F-320 and to evaluate its material performance and container performance under various environmental conditions and as containers in unit loads.

The new fiberboard and the V3c control fiberboard were tested in accordance with American Society for Testing Materials standards or with the requirements of Federal Specifications, utilizing five various environmental conditions. Both materials were tested for ply separation, water absorption, scoreability and bending, bursting strength (wet and dry), and basis weight. Containers made of both materials were subjected to drop tests and compression tests after conditioning. Small size unit loads of both types of containers, sheathed and capped with V2s solid fiberboard, were given compression tests after environmental conditioning.

It was found that the performance of the new material, because of the wet strength kraft used for the corrugating medium instead of virgin or reclaimed fiber corrugating medium, was superior to the V3c material in water absorption, wet Mullen, and in container drop tests after water spray conditions. The container drop tests performances after total immersion were very similar. The V3c containers slightly outperformed the new material containers in compression strength after long periods of storage at high temperatures and humidities; however, the new material showed greater durability under water spray and total immersion conditions.

DD FORM 1 NOV 65 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

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14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Physical Properties	8					
Separation	8		7			
Moistureproofing	8		7			
Bursting Strength	8		7			
Weight	8		7			
Wet Strength	8		7			
Impact Strength	8		7			
Compression	8		7			
Fiberboard	9		7			
Corrugated	0		7			
Single-wall	0		7			
Containers	4		7			
Southeast Asia	4		6			
Heat			6			
Humidity			6			